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ABSTRACT

The potential role of radio and television in improving equity and efficiency in the delivery of education in developing countries is discussed. The following four sections discuss major educational issues and reforms involving the use of instructional television and radio in countries such as American Samoa, El Salvador, and the Ivory Coast: (1) alternatives open in organizing a formal schooling system, with emphasis on the technological alternatives; (2) available evidence on the effectiveness of a number of the alternatives; (3) a summary of available information on the costs of instructional radio and television; and (4) some policy implications from the cost-effectiveness summaries. (CHV)

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RESEARCH MEMORANDUM

RADIO AND TELEVISION FOR EDUCATION IN DEVELOPING COUNTRIES

Dean T. Jamison

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RADIO AND TELEVISION FOR EDUCATION IN DEVELOPING COUNTRIES*

by

Dean T. Jamison

My purpose in this paper is to discuss the potential role that radio and television have in improving equity and efficiency in the delivery of education in developing countries. In several countries- American Samoa, El Salvador, and the Ivory Coast - there have been major educational reforms involving the use of television, and a large number of countries make at least sporadic use of instructional radio. Thus there is growing experience with at least some uses of these media for education; this experience provides the basis for a preliminary assessment of how widespread a role instructional radio (IR) and instructional television (ITV) should play in educational development in the years to come.

Section I of this paper outlines the alternatives open in organizing a formal schooling system, with emphasis on the technological alternatives. Section II discusses the available evidence on the effectiveness of a number of the alternatives, and Section III summarizes available information on the costs of IR and ITV. Finally, Section IV draws some policy implications from the cost and effectiveness summaries.

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* The original version of this paper was prepared in October, 1973, for a World Bank Workshop on the Economics of Education.

I. ALTERNATIVES FOR FORMAL EDUCATION

In this section I describe in broad terms the alternatives for formal education in terms of its internal organization. I first categorize these alternatives along a number of dimensions and then more specifically discuss the alternatives on the dimension most critical for cost-effectiveness analysis. That dimension concerns the mix of instructional technologies which has the most direct impact on cost. The set of alternatives actually available to a decision maker depends, of course, on his budget and other constraints; the final subsection discusses modeling the effects of the budget constraint in more detail.

Categorization of Alternatives*

The categories of alternatives that I will use are:

1. degree of physical centralization,
2. mix of instructional methods (including the conventional classroom),
3. amount of time the student spends in school,
4. curriculum mix, and
5. certification, promotion, and retention procedures.

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*A category that will not be discussed here is that of organizational alternatives. In the United States there is discussion of a number of organizational structures differing from those now in common use; these include performance contracting, community control, and voucher finance.

I discuss each of these briefly below, then focus in more detail on those most critical for a cost-effectiveness analysis.

Advances in communication and information storage technology have made possible a considerable decentralization of schools. A first level of decentralization would be to perhaps very small neighborhood schools. A more marked level of decentralization would be to the correspondence-school concept where the students receive their lessons at home by audio or video (stored or off the air) and interact with the school system by mail or, for developed countries, through their own terminals. This form of instruction is called 'distance learning' by the British, and it is increasingly widely used. Distance learning need not preclude gatherings of students for athletics, social occasions, or seminars and discussions. Going in the other direction, one can conceive much larger school groupings than now exist; one argument in favor of these larger groupings might be to promote social and racial integration.

My own guess is that at the elementary level there are only very limited productivity implications for several fold increases or decreases in the present sizes of schools, though I feel this issue should be further examined. Further, in the rural areas that predominate in developing countries, there may be little choice about the size of schools unless one wishes to consider extensive student transportation and residential schools.

The second category of alternatives concerns the mix of instructional methods. I use the term mix to emphasize that in most departures from the present method of instruction the student will be learning from several

instructional techniques during the day. In one mix there might, for example, be 2 hours of ITV in a class of size 60 with one para-professional and one older student monitoring, 2 hours of conventional class activity (size 27), and 1/2 hour with a teacher in a discussion group with 5 or 6 other students. Clearly a great many mixes can be built from the basic array of technological and organizational alternatives now available, and we discuss these possibilities in more detail in the following subsections.

The third dimension of alternatives concerns the amount of time students spend in school--the number of hours per day and the number of days per year. In most countries elementary students spend 4 to 6 hours per day for about 180 days. Using present techniques of instruction, the length of the school year impacts very strongly indeed on costs and it is probably of considerable importance in student learning, as will be discussed in Section II. There is one further aspect of the 'time' question that is much discussed by economists. For students in the higher grade levels, it is argued, there is an opportunity cost to the economy of having the student in school. In estimating the true cost of education one should, then, add in the earnings foregone by students due to their being in school. In an overview of results in this area Schultz (1971) estimates that approximately half the cost of schooling at the upper levels in developing countries may be in earnings foregone. Increasing problems of educated unemployment reduce these costs, however. In the discussion of costs in this paper I will simply note the amount of school time required of students without attempting to assign a value to it.

The final category of alternatives concerns promotion, retention, and certification procedures. The range of options here depends to some extent on the state of testing technology. Though testing and certification procedures have only a small direct impact on cost, they have an important indirect impact through their influence on the number of students in the system. We return to this point later in this section where drop-out and promotion rates play a central role in evaluation of the alternative.

Mixes of Instructional Methods

The second dimension of alternatives we discussed in Section II.A concerned the mix of instructional methods, construed to include the present method of instruction that involves a teacher in front of a classroom of students as well as various technologies. I first sketch the conventional alternatives, then the technological ones.

Conventional Alternatives. The conventional alternatives to the present system fall into several relatively simple categories. These are:

1. Changes in teacher quality (i.e., level of intelligence, education, or experience).
2. Changes in the average number of students per class.
3. Changes in the average number of hours per week and weeks per year the student spends in school.
4. Changes in the utilization rate of classrooms.

The feasible conventional alternatives can be characterized for any given annual budget for primary education, B, and number of students to be enrolled, N. Let q be a measure of teacher quality (for operational simplicity, q may have to be a simple measure such as percentage of teachers fully qualified at average educational attainment of teachers) and let W(q) be the average annual wage (for full time work) of teachers when their quality average is q. Let C be the average class size, i.e., the average number of students in a classroom with a teacher and let h be the average number of hours per week a student is in class. Assuming, and this assumption can easily be relaxed, that a full-time teacher is in class 36 hours per week, the student to teacher ratio, S, is given by:

$$S = 36C/h \ . \qquad (1)$$

Increasing class size thus increases S, as does decreasing h.

To continue, let U be the average usage rate of classrooms, i.e., the average number of times they are used per day and let P be an imputed annual price for a classroom. Since the available budget was B and the number of students was N, an average of B/N per student per year is the basic cost constraint. Each student consumes 1/S or h/36C teachers and 1/UC classrooms during the year. Thus the following equation holds as an approximation that includes only the major costs:

$$N[(h/36C)W(q) + P/UC] = B \ . \qquad (2)$$

Equation 2 summarizes all "conventional" alternatives for the primary system in broadbrush terms. It fails to capture nuances but it specifies, nonetheless, all combinations of teacher quality, class size, hours of class per week, classroom usage rate, and students enrolled, that are economically feasible at the prevailing budget, prices, and wages.

Technological Alternatives. It is somewhat more difficult to categorize the technological alternatives than to categorize the conventional ones. There seem to be two broad dimensions along which the alternatives can be arrayed. The first is alternative technologies and the second is alternative uses for technology. Alternative technologies include:

1. Television.
2. Blackboard or still frame television, i.e., television that presents only alphanumeric characters or line drawings on the one hand or still pictures on the other.
3. Classroom controlled audio-visual media, including tape cassette players.
4. Radio.
5. Computer-assisted and computer-managed instruction (CAI and CMI; with CAI the student is on-line to the computer, with CMI he is off-line).
6. Programmed self-instruction.

Alternative uses for technology include at least the following four possibilities:

1. Enrichment of learning, i.e., provision of occasional lessons or experiences that the classroom teacher cannot easily provide.
2. Total replacement of the teacher in one or more subject areas.

3. Substantial supplementation of the teacher in one or more subject areas.

4. Distance learning.

Schramm, Coombs, Kahnert, and Lyle, (1967a,b) review instances where new media have been used for many of these tasks; and Schramm (1973) provides an up-to-date account of a number of more recent efforts, particularly with distance learning.

Modeling the Effects of Alternative Budgets and Options

The purpose of this section is to outline a model that can be constructed to project the number of enrollees, graduates, and dropouts of the elementary education system as a function of budget levels, drop-out rates, repetition rates, and the extent and manner in which IR and ITV are used. The output of the system in a given year can be considered to be the function that gives the number of school leavers at any given level. The term 'level' here could be understood in terms of cognitive or affective states, but for purposes of this model, we will use it to mean grade level. The output function for year t, $f_t(g)$, will then give the number of students who leave school in year t after having completed the gth grade. The purpose of the model will, then, be to project $f_t(g)$ as a function of budgets and other parameters. (The next step beyond projection would be to make the model explicitly optimizing, in terms either of maximizing present value of output - e.g., Bowles (1969) - or minimizing cost - e.g., Schiefelbein and Davis (1974). The rationale for using simulation rather than optimization models is that optimizing models are substantially more difficult to implement and provide little additional information. The extent to which this rationale is correct remains debatable.)

The model outlined here extends one previously developed* to analyze the potential impact of introducing radio in the elementary education system of Indonesia. The approach taken in that model has two advantages over other, somewhat similar models.** First, it is designed to allow assessment of the cost and performance impact of the introduction of educational technology. Second, it is designed with budget levels exogenous, rather than endogenous; this has the advantage of allowing examination of output trade-offs for a fixed budget (or rate of growth of budget).

Figure 1 on the next page provides a flow diagram for the model; a more detailed algebraic statement of it (in a preliminary form) may be found in the previously footnoted paper by Jamison.

The purpose in sketching this model is to illustrate, first, the manner in which media mix impacts on output both directly and through its effects on learning and second, the manner in which it impacts on costs and hence the number of students that can be accommodated with a given budget. To implement such a model fully requires more empirical information than is yet available on the effects of media mix and time of

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*See D. Jamison, "Alternative strategies for primary education in Indonesia: A cost-effectiveness analysis," Research Paper 46, Stanford University Graduate School of Business, 1971.

**See the following: "The UNESCO Educational Simulation Model," Reports and Papers in the Social Sciences, No. 29, UNESCO, 1974; Ta Ngoc Chau, Population Growth and Costs of Education in Developing Countries, International Institute for Educational Planning, Paris, 1972; L. Goreux, "A Model of Secondary Education in Ivory Coast," The World Bank, forthcoming. For surveys of some of these and related models, see Mathematical Models for the Education Sector: A Survey, OECD, 1973, or M. Malita and C. Zidaroiu, Modele Matematice ale Sistemului Educational, ETURA Didactica si Pedagogica, Bucharest, 1972.

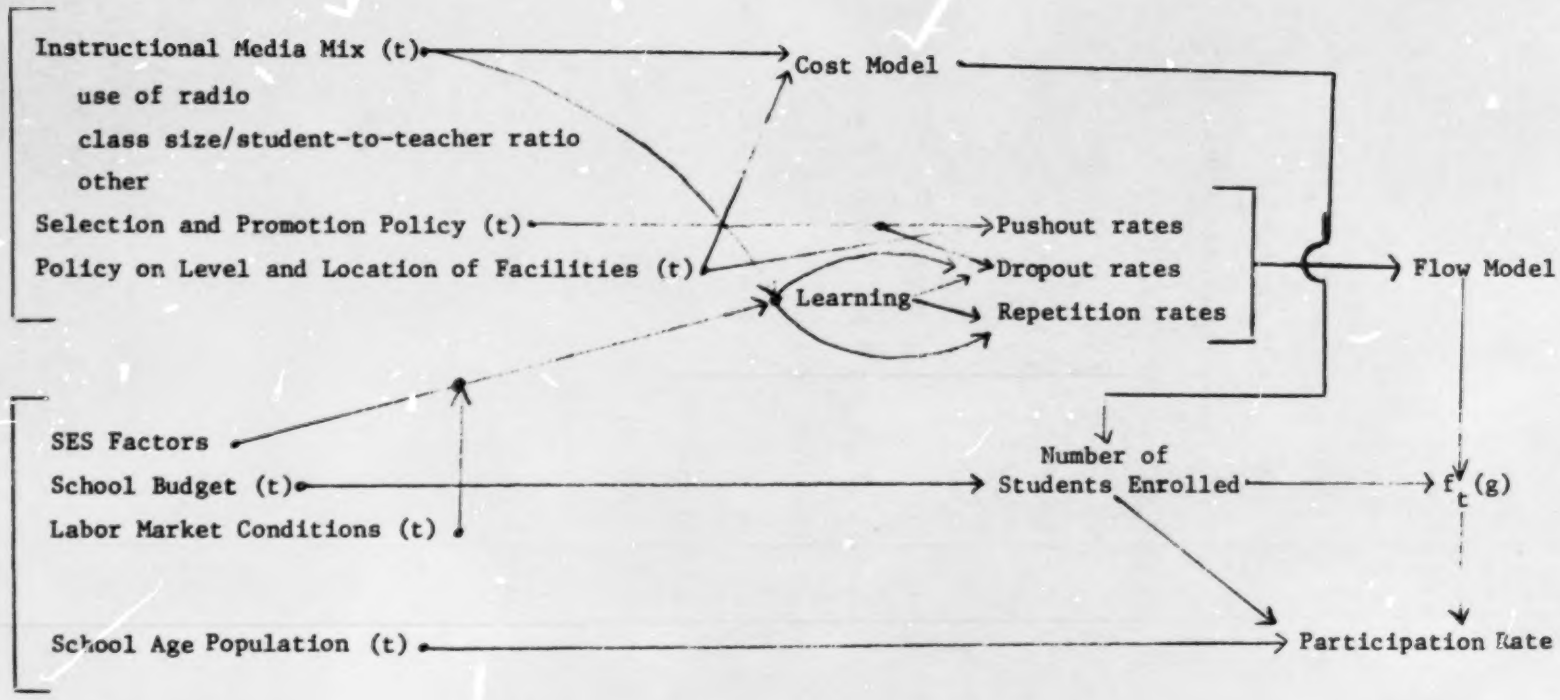

Figure 1: Schematic of Simulation Model for Elementary Education

Notes:
1. 't' is appended to a number of variables to indicate time dependence.
2. The term 'pushout' is used to denote individuals forced by the system (purposely or not) to discontinue their schooling.
3. A more refined version of the model will include analysis of teacher training institutions.

exposure on student learning and demand for schooling. Still, much is known about media effects, and this is summarized in the next section.

II. EFFECTIVENESS

This section summarizes available information on the instructional effectiveness of alternative media. It is drawn entirely from a recent paper on "The effectiveness of alternative instructional media: A survey" that I coauthored with Patrick Suppes and Stuart Wells (1974); this paper will be denoted JSW.

Traditional Instruction (JSW, pp. 26 - 27)

> "In concluding this survey on the effectiveness of traditional classroom instruction, it seems reasonable to conclude that few variables consistently make a difference in student performance; the 16 variables examined in Table 1 support this generalization. The student-to-teacher ratio is perhaps the most economically relevant variable under a school system's control, and the 23 recent studies summarized in Table 2 strengthen the conclusions of earlier studies that concluded that the student-to-teacher ratio has little influence on student learning. Exceptions to these general conclusions would be that teacher verbal ability appears important in a high fraction of the instances examined, and that small classes seem to improve the cognitive and affective performance of young children. These conclusions do not, however, imply that schools make no difference in the cognitive development of their students; on the contrary, school attendance is clearly important in promoting academic achievement though few studies seem to have examined this issue. What remains to be demonstrated is that variations in traditional school inputs are consistently related to variations in school outputs."

Instructional Radio (JSW, pp. 33 - 34)

> "Radio has been used extensively for formal classroom instruction in the United States (more in the past than at present) and elsewhere. There exist, however, only a limited number of good evaluations of the effectiveness of instructional radio. These evaluations indicate that instructional radio (supplemented with appropriate printed material) can be used to teach most subjects as effectively as a live classroom instructor or ITV. Due to the limited number and scope of good evaluations now available, and to the potential economic significance of instructional radio for developing countries, much more research -- both survey and experimental -- is highly desirable."

Instructional Television (JSW, p. 38)

> "ITV can teach all grade levels and subject matters about as effectively as traditional instruction, though some evidence indicates that it performs relatively better at lower grade levels. A significant fraction of teachers and students have initially negative attitudes toward ITV; these negative attitudes tend to lessen, but not necessarily disappear, with time and appropriate administrative behavior. Evaluations that report no significant difference between ITV and traditional instruction are usually based on experimental designs that hold almost everything but the medium constant. It is plausible--though not, to our knowledge, experimentally verified--that attempts to use the distinctive potential of the television medium would result in more systematic findings of significant differences between ITV and alternative treatment groups."

The above quotes dealt with the effect of media mix on cognitive learning; relatively speaking a good deal is known about these effects. Essentially, if an individual is exposed to instruction, by whatever medium, he will learn, and the amount he learns seems little affected by the medium. Two other questions are important, however, in assessing effectiveness, but less well researched. The first concerns the effect of time on amount of exposure* on learning, and the second concerns the effects of

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*Carroll (1963) advanced a model of school learning that places time of exposure in a central role and Wiley (1973) found empirical evidence to support the importance of the time variable.

media mix and instructional quality on student drop-out propensity.* Only the second of these affects decisions about choice of media, but the available research is insufficient to provide much of a guide.

III. COST OF INSTRUCTIONAL RADIO AND TELEVISION

For a general feeling for the magnitude and relationship between the costs of ITV and IR a study of the General Learning Corporation (1968) is useful. They estimated the costs of different instructional media systems for different audience sizes and different levels of program production quality, assuming rather extensive production--from 1000 hours (for a small population) to 1600 hours (for a large population)--of instructional materials, distributed through twelve grades of school. Costs per student at the higher ranges of student utilization increase somewhat due to the additional signal distribution costs of broadcasting to a lower density population (there is also an assumed increase in program quality for metropolitan regions and larger, but this factor merely slows the rate of decrease in program production costs per student and is not the cause of the trend-reversal). Examining these system costs on a per student-hour viewed basis shows that for reasonably large audiences (city and larger), the costs of ITV run three to five times greater than those of IR--ranging from 5¢ to 10¢ per student-hour for ITV and from 1.5¢ to 2.5¢ per student-hour for IR.

The cost estimates developed in the General Learning Corporation study discussed above were for hypothetical systems and oriented mainly

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*Beirn, Kinsey, and McGinn (1971) and Brimer and Pauli (1971) have reviewed the research on dropping out and its determinants.

towards the needs and capabilities of a relatively developed nation. The use of these technologies in developing countries, where information on costs that have actually been incurred is available and different types of media systems would most likely be used (e.g., open-circut VHF ITV), is perhaps of interest. Furthermore, since there is often a considerable difference between costs in theory and costs in practice, this type of analysis is essential.

Jamison and Klees (in press) examined cost case studies for five ITV projects and three IR projects and attempted to put the data on a comparable basis. Their summary table is reproduced here as Table 1 and their relevant concluding comments are as follows:

> 1. It is realistic to expect the costs of instructional television to range from 1.5¢ to 15¢ per student per hour, depending most importantly on the number of students in the system. The low end of this range can only be reached if close to a million students are using the system in a reasonably compact geographical area.
>
> 2. It is realistic to expect the costs of instructional radio to range from 1/3¢ to 3¢ or 4¢ per student per hour, about one-fifth as much as instructional television. The high end of this range can be reached with very small numbers of students (several thousand); the low end might require several hundred thousand.

The cost estimates made by Jamison and Klees (except for American Samoa's ITV project and Mexico's IR project which have abnormally low student utilization rates) seem to compare reasonably well with the estimates made by the General Learning Corporation study.

To place these costs in context, it is worth noting how much the average student to teacher ratio would need to raise in order to keep per student costs constant if a typical technology (costing,

TABLE 1

COST SUMMARY OF 5 INSTRUCTIONAL TELEVISION AND 3 INSTRUCTIONAL RADIO PROJECTS[a,b]

Project	Year of Information Source	N	h	F	V	AC	AC/V	Student-Hr. Cost
A. ITV								
Colombia	1965	275,000	50.25	624,000	.859	3.13	3.95	.062
American Samoa	1972	8,100	145	1,268,000	3.06	159.60	52.2	1.10
Mexico	1972	29,000	360	598,000	4.23	24.85	5.87	.069
El Salvador (Sec. Only)	1972	48,000	170	1,116,000	1.10	24.35	22.14	.143
Ivory Coast	1970	745,000[c]	180	2,454,000	3.98	7.27	1.83	.040
B. IR								
Thailand	1967	800,000	25	100,400	.221	.347	1.57	.014
Mexico	1973	2,800	233	37,700	.11	13.57	123.40	.058
Indonesia[c]	1971	1,200,000	100	102,400	.32	.41	1.27	.0041

[a]Values in this table were computed with a social discount rate of 7.5%; all values are in 1972 U. S. dollars.

[b]The symbols are defined as follows: N = number of students using project (in the given year, unless otherwise noted); h = number of hours per year a typical student views programs; F = annualized fixed costs; V = annualized per student variable costs; AC = average cost per student for the given value of N; and the student-hr. cost is the cost per student-hour of viewing for the given value of N. The model underlying use of F and V to characterize the cost behavior of the system is an approximate one assuming that total cost = F + VN. Since average cost equals total cost divided by N, AC = F/N + V.

[c]The Indonesia figures are based on a planning study, not project experience.

SOURCE: Jamison and Klees in press, Tables III.1 & 2.

say, 2.5¢ per hour for one hour each school day) were introduced. This depends, of course, on the original class size and teacher's annual wage; assuming an initial class size of 25 and a teacher wage of $750 per year, the student to teacher ratio would need to rise by 4.4 to keep costs constant (Jamison and Klees, Appendix). If the teacher wage were $1500, the student to teacher ratio would need to rise by only 2.03.

IV. IMPLICATIONS FOR POLICY

Elementary Education

Elementary schools in developing countries face a well-known complex of problems including rising unit costs, inadequate student learning, and incomplete coverage of the elementary school age population. The instructional methods they employ differ very little worldwide: a poorly trained teacher dictates or lectures to a class of 25 to 50 students for 20 to 30 hours per week. The students have only limited access to printed material. What are the implications of continuing with these methods? What are the alternatives?

If these methods continue we can expect rising unit costs resulting from teacher salary increases that will occur at at least the rate of increase of per capita income. Quality might improve slightly through better teacher training but this appears somewhat unlikely. If school budgets grow at approximately the rate of national income (and, of course, they cannot long continue to grow at higher rates) then no greater fraction of students than now will have access to elementary school. Thus, in terms of the model of Figure 1, we could expect to continue to see high

dropout and repetition rates, and, because of increasing per student costs, no progress in reducing inequality despite potentially major increases in the real allocation to schooling.

Are there alternatives? I think that extensive use of radio for classroom instruction may turn out to be a highly viable alternative. It is effective, as effective as a well-trained classroom teacher (see Section II). It is plausible (but unproved) that good programming could make it substantially more effective than a good teacher. Its costs can be low. Its use should be paid for by increasing average class size and decreasing the number of hours per week students spend in class. If this were done unit costs could go down and learning up; the ensuing combination of lower repetition rates and large enrollments would dramatically increase system throughput. Use of a broadcast medium has the additional advantage of allowing rapid curriculum change in response to social need.

Are there other alternatives? TV is a possibility, but there is no evidence that it is more instructionally effective than radio and its cost is apt to be 10 times as great. It will almost inevitably increase unit costs, and it may do so dramatically (as it has in the Ivory Coast). Thus, for a fixed school budget, it would tend to increase inequality. Another possibility is to raise class sizes and shorten hours of attendance without incurring the cost of simultaneously introducing radio. This would probably improve throughput in the short run by increasing enrollment, but it fails to allow for the very substantial efficiency improvements that could result from reduced wastage. I conclude that heavy utilization of radio is apt to be the best approach to improve equity and efficiency in

elementary education. This conclusion is subject, however, to the major caution that systematic use of radio in this way remains to be tried operationally.*

Secondary and Higher Education

At present, secondary and higher education are far more costly than elementary, are received primarily by the already relatively well-off, and are available principally in population centers. The poor and the rural are to a large extent denied access. With an inequality averse utility function the only way to justify expenditure above the elementary level is to have those expenditures be so efficiently spent that the cost of advancing a student a grade is less than at the elementary level. Continued expenditures on more or less the present methods of providing secondary and higher education will, then, contribute to continued inequality and selective education for the better-off urban populations.

An alternative to the above could be shaped along the lines just advocated for the elementary level. I think this would have two important disadvantages. First it could not reduce costs sufficiently to have secondary or higher education justify receiving resources at the cost of elementary education (if we are genuinely inequality averse). Second it could not economically provide education in rural areas if we assume that a substantially smaller fraction of students will receive secondary than elementary education. (This is because of inherent economies of scale, up to a point, in running a school with any diversity of course offerings.)

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*The U.S. Agency for International Development is funding a Radio Mathematics Project in Nicaragua that will provide important, though limited information on the viability of radio for educational reform.

The alternative I would propose for virtually all secondary and higher education is radio-correspondence instruction -- low cost versions of the Open University, if you wish. For reasons of cost, this distance learning should be based on radio rather than television. There is no question but that students can learn and learn well from these systems (Schramm, 1973, Chapter VI). Costs can be a tenth to a half that of existing systems. Rural coverage is almost as easy as urban. The system could be designed to allow students to work while studying thus making schooling available to able poor students who would otherwise be unable to finance it. Access could fairly quickly be universal, eliminating the need for anything other than self-selection for post-elementary education. Adults could easily return to schooling. Curriculum change could adapt easily to changing economic and social needs.

What I would recommend, then, would be:

1. Freeze secondary school and university building construction, teacher training, or teacher hiring. Finance research in other ways than through university faculty salaries.

2. Create nationwide open schooling systems based on radio and correspondence. Build this up first in rural areas where the need is greatest even though per student costs will be higher.

While these recommendations probably put the case too strongly, and will be much less applicable for some countries than for others, they seem to me to point clearly in the directions of both greater efficiency and greater equity.

Implications for Donor Agencies

It is clear that the proposals of the two preceding subsections will be politically unacceptable, at least for the time being, to most decision makers in most developing countries. This unacceptability results from some

mix of interest group pressure and conviction that continuation of traditional methods is the correct way to proceed. Donor agency policy should be oriented toward assisting in every possible way those relatively few decision makers who wish to improve equity and efficiency by use of low cost media, and toward educating the rest. In particular donor agencies should:

1. Subsidize experimentation with the development and implementation of radio based curriculums at the elementary level, and help insure that sufficient planning is done so that these efforts are cost effective. They should subsidize little else at the elementary level.

2. Subsidize the creation of open learning systems for rural populations at the secondary and higher levels. They should subsidize little else at these levels.

3. Continue existing and initiate new research concerning the design and impact of radio based learning systems.

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